may prevent their ever becoming scientific. Intolerance of those who have the gift of imagination may lead one to try to suppress a Davy or a Maxwell.

Public dissatisfaction with the teaching of to-day is expressed by many. Let me quote a few.

L. B. Avery, of California:

Physics is the most fundamental in its conceptions and the most practical in its applications of all the sciences. The proposition to leave any portion of those who take a complete high school course with no knowledge of it is in itself a complete acknowledgment of the educational inadequacy of the present methods.

L. H. Bailey, of Cornell:

Distinguish between the teaching function and the research function. We are teachers. It is our business to open the minds of the young to the facts of science. . . . Nature study is a new mode of teaching, not a new subject. It is just as applicable to the college as to the common school. . . . We should be interested more in the student than in the science.

T. M. Balliet, of New York University, in *School Review*, Vol. 16, p. 217, has an exceedingly good article, but too long to quote, on "The [evil] Influence of Present Methods of Graduate Instruction on the Teaching in Secondary Schools."

W. S. Franklin, of Lehigh:

My experience is, most emphatically, that a student may measure a thing and know nothing at all about it and I believe that the present high school courses in elementary physics in which quantitative laboratory work is so strongly emphasized, are altogether bad. . . . I believe that physical sciences should be taught in the secondary schools with reference primarily to their practical applications. . . . I can not endure a so-called knowledge of elementary science which does not relate to some actual physical condition or thing. . . . Either you must create an actual world of the unusual phenomena of nature by purchasing an elaborate and expensive equipment of scientific apparatus, or you must make use of the boy's everyday world of actual conditions and things.

David Starr Jordan, of Leland Stanford University:

For colleges to specify certain classes of subjects regardless of the real interest of the secondary schools and their pupils is a species of impertinence which only tradition justifies. . . . In general, the high-school graduate who has a training worth while in the conduct of life is also well-fitted to enter college for further training. The average American boy quits the high school in disgust because he can not interpret its work in terms of life.

S. V. Kellerman:

Only by teaching honestly what the world needs, and can use, may the schools accomplish their lofty aims.

No one has stated the dissatisfaction with present practises more justly than Principal W. D. Lewis in the *Outlook*, December 11, 1909, in an article entitled "College Domination of High Schools," from which I make an extract or two.

The high school is failing in its mission because its methods and scope of instruction are determined by college entrance examinations made by specialists whose point of view is not the welfare of the student, but the (supposed) requirements for advanced study of certain subjects. . . . Our present college-dictated high-school course is ill adapted to the real needs of the people in that it places the emphasis on the wrong subjects, and practically eliminates those that would be of the greatest practical value in the lives of the vast majority of pupils whose only opportunity for higher education is in the public high school. No less destructive of the welfare of the masses is the limitation in method of treatment of the subjects taught. . . . College teachers have written the courses, trained the teachers, set the examinations and execrated the results.

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FOUR INSTRUMENTS OF CONFUSION IN TEACHING PHYSICS[1]

THE college entrance requirements in physics have been such, at least up to the time of the recent modifications, that it has

[1] Read before Section L, Boston, 1909.

been practically impossible to meet them in any satisfactory manner in schools in which, as is the case, for instance, in the free high schools of Wisconsin, the subject is almost universally a required one. Even the new requirements are still so largely quantitative in their spirit that there is great room for doubt as to the advisability of attempting to prepare for college unless the doubtful practise, so commonly being adopted, of making the college preparatory an elective course is to prevail. This would mean that if pupils are to be given to any adequate extent the wider view of life and its relations, with a permanent interest in the natural phenomena about them, separate classes must be formed whose work will not count as a preparation for study in a higher school.

The results up to this time of the attempts to give to all students a general course which would meet the two purposes have been far from satisfactory from the standpoint of either life or the college. Neither interest nor ability has, as a rule, been developed. Even in schools having special preparatory classes the subject is elected by comparatively few and the number taking it because they really like it, is much smaller still. On the other hand, the attempt to make the general class meet the requirements has resulted in very imperfect ideas coupled too often with an actual dislike of anything related to the distorted meaning attached to the word physics.

I will illustrate by describing a typical case. A young lady with whom I am well acquainted was studying physics, not in the backwoods, but in a large school in the shadow of what is by common consent considered a great university. The class was in charge of a well-educated young man who has since been promoted to a still better position. In conversation with the young lady I asked her to tell me in plain English the meaning of specific gravity. To make the question more concrete I used a piece of wood as an illustration, and asked what is meant when we say its specific gravity is .6. She began by giving me correctly the formal definition: "Specific gravity is the ratio, etc." This was not plain, every-day, common English. Then she told me how to find specific gravity. This would have no meaning to a person who had never studied physics. She finally gave up in despair, and I suggested that the expression meant simply, in the case under consideration, that the piece of wood weighed .6 as much as the same bulk of water. In almost astonishment she declared that she had never thought of it in that way before.

Judging from the answers to this and many similar questions received from hundreds of pupils I feel that I am safe in saying that this was a case typical of the large majority. The student was, I think, certainly up to the average in ability to comprehend physics, and she had a natural liking for the subject. At any rate, she can now talk intelligently of the carburetor, throttle and needle valves, fly wheel and mixture of air and gas of the motor of her launch, and, moreover, the little engine responds more readily to her touch than it does to that of others who might be supposed to be better qualified than she in physics. She even fully appreciates the advantage of the system of pulleys used to lift the door of the boat house. She is now a senior in the university, but her dislike for the study is such that she has refused to elect it in her course, even though she might have taken it under one of the most skilful and interesting professors in the whole country. I do not mean to imply that the work is all

poor, but the results as a whole are not nearly what they should be.

Now, in studying the general situation and especially in analyzing the means used in teaching, aside from the influence of the personality of the teacher, I can not help concluding that the great defect lies largely in the misuse of the four great tools of instruction, fine tools in their proper place and used at the proper time, but as used in our high schools under the conditions existing in Wisconsin, at least, turned to what may be fitly called instruments of confusion. These instruments are:

1. *Measurement.*—Undue emphasis is placed upon accurate measurement, especially with delicate and complicated apparatus. I suppose that in the case described above the pupil had been put through the usual course. There was first some brief introductory work, mainly by the teacher, with little attempt to make use of what the student already knew of the subject. Instead of some roughly approximate measurements using a familiar spring balance, a large block of some substance and a tank of water, she was probably given a carefully adjusted balance, a small bit of some material, and required to make from ten to twenty weighings, to average the results, and to write the whole according to a prescribed form in a notebook. She was fortunate if the time of the instruction and the time of the laboratory work were not some days or even weeks apart. By the time all this was done the poor little bit of physics involved was pretty effectually lost in the maze of manipulations and averages. It may have been excellent manual-training work, but it should have been done in that department.

Laboratory work is necessary, more necessary in these days of specialization than ever before, not as a specialist's instrument in the high school, but as a means of giving clearer conceptions of the topics studied, including supplying information which in earlier days would have come to the pupil as a part of his own experience. Much of physics which a generation or two ago was within the observation of the pupil in its entirety is now largely obscured. For instance, in the case of the water supply. Then the boy saw the well dug, the pump and piping installed, and the water obtained by the application of force; now he sees only the faucet. Then, the periodical candle making from tallow produced on the farm was a somewhat exciting event, upon the success or failure of which meant a good or poor supply of light for the winter evenings; now, a button is pushed and the light comes without further question. The chain back to the source must be supplied by the laboratory work, a large part of which still should be outside of school.

2. *The Mathematical Work.*—The average exercise in the texts most in use when analyzed reveals a very small amount of physics in proportion to the mathematics involved. It would make excellent material for a parallel advanced class in mathematics, either algebra or geometry, or a combination of the two. I am hoping to see the experiment tried of having such classes conducted, if possible, by the teachers of physics, but such work should not take the time of or be called physics.

Physics is a quantitative as well as a qualitative study, and we must use some mathematics; but in my experience, both as a teacher and as an inspector, I have found that the mathematics must be very simple, and that round numbers, or very simple fractions, must be generally used if the pupil's mind is to be kept clear for the physical principle. The experiment illustrating Boyle's law will be much

clearer if the confined gas be reduced to approximately a half, a third, or a quarter, than if a smaller or a more closely accurate measurement be attempted.

3. *The Formula.*—Over and over I find pupils using formulas and securing correct answers to problems without any definite comprehension of the meaning of the formula, the principles and phenomena involved, or of the answer obtained. I might give many illustrations drawn from experience, but he is a fortunate and an excellent teacher who can not secure illustrations by asking his own pupils for explanations in clear, understandable, everyday English. Teachers do not appear to realize that a formula is an instrument to save thinking, and that its use very soon becomes purely mechanical, as in the case of any rule-of-thumb process. In the hands of a beginner it is a dangerous tool if he is expected to become an intelligent, independent man rather than a mere workman.

4. *Technical Terms.*—These employed to the usual extent are the most dangerous of all instruments in their possible effects. More time is wasted in science classes in mere dictionary work than one can realize unless he has had opportunity for extended observation. Instead of starting with the phenomenon, the thing itself, and gradually reaching a point of understanding such that a single word may be used instead of a group to express a thought and still keep the thought in mind, the teacher is all too likely to begin with the technical word and attempt to work backward in getting at the idea. Here again is the failure to understand that the symbol is a time-saving device, and that it is utterly useless without the clear idea always back of it. The accumulation of the mass of technical terms in the most of our secondary science teaching is almost appalling, and it is no wonder that so many pupils emerge at the end of the study in the bewildered condition indicated by the examination tests.

Physics is a study most wonderful in its possibilities, and I sincerely hope that in the near future the work may be so modified that its usefulness will appeal to our students so strongly that we may be able to resist the demand that it be made an optional study.

The average American young person is very unwilling to give up what he considers his birthright, the opportunity for a higher education; and he submits to much that is distasteful and to much which he instinctively feels is inappropriate or useless rather than to forfeit a chance of satisfying what may be an ambition in the future. Must it continue necessary, in order to fit for college, that the four great instruments for giving that preparation shall continue to be "Instruments of Confusion"?

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THE RESIGNATION OF PRESIDENT NEEDHAM

Dr. Charles W. Needham has resigned the presidency of George Washington University. In his letter to the trustees he says:

> After eight years of service as president I offer my resignation of this high office. This I do from a keen sense of personal loyalty to the institution. Difficulties have arisen which, in my own opinion and in the opinion of some of my friends in whom I have the greatest confidence, can only be solved by a man coming to this office who can undertake the task free from all connection with the past. It therefore becomes my duty to make clear the way for the appointment of such a man.

In accepting the resignation the trustees passed the following resolution:

> *Resolved,* That the resignation of Dr. Charles Willis Needham as the president of this univer-